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SIMULATOR TRAINING REQUIREMENTS AND EFFECTIVENESS STUDY (STRES): EXECUTIVE SUMMARY

By

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LOGISTICS AND TECHNICAL TRAINING DIVISION
Logistics Research Branch
Wright-Patterson Air Force Base, Ohio 45433

January 1981

Final Report

Approved for public release; distribution unlimited.

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

NOTICE

This final report was submitted by Canyon Research Group, Inc., 741 Lakefield Road, Suite B, Westlake Village, California 91361, under Contract F33615-77-C-0067, Project 1710, with the Logistics and Technical Training Division, Air Force Human Resources Laboratory (AFSC), Wright-Patterson Air Force Base, Ohio 45433. Mr. Bertram W. Cream was the Contract Monitor for the Laboratory.

This technical report has been reviewed and is approved for publication.

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Commander

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Seven technical reports have been prepared to date for the Simulator Training Requirements and Effectiveness Study (STRES). One is this Executive Summary, which is designed to serve two purposes. One purpose is to summarize the content of the other six reports, which address the following aircrew training device (ATD) issues: ATD fidelity; instructional support features; utilization of ATDs in aircrew training programs; ATD life cycle costs; and worth of ownership. Program objectives in each area are set forth, together with summaries of technical report content dealing with each objective. Additional topics addressed are plans for future research and the abstract bibliography that was prepared as part of the program. The second purpose of the Executive Summary

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report is to present a master index to other program technical reports so that readers have a unified source for identifying detailed information bearing on training device information covered in other program technical reports.

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PREFACE

This report describes a portion of a study of Air Force aircrew training using simulation as one part of a total training system. The study was initiated in response to a Request for Personnel Research (RPR-77-9) from Headquarters, USAF (AF/XOOTD).

This is one of seven technical reports prepared for the Air Force Human Resources Laboratory, Advanced Systems Division, under Contract F33615-77-C-0067, Simulator Training Requirements and Effectiveness Study (STRES). The reports are identified in Chapter II of this document.

The work was performed from August 1977 through February 1980 by a team made up of Canyon Research Group, Inc.; Seville Research Corporation; and United Airlines Flight Training Center. Canyon Research Group, Inc. was the prime contractor; Mr. Clarence A. Semple was the Program Manager. The Seville Research Corporation effort was headed by Dr. Paul W. Caro. The United Airlines effort was headed initially by Mr. Dale L. Seay and subsequently by Mr. Kenneth E. Allbee.

Mr. Bertram W. Cream was the AFHRL/AS Program Manager. Other key members of the AFHRL/AS technical team included Dr. Thomas Eggemeier and Dr. Gary Klein. A tri-service STRES Advisory Team participated in guiding and monitoring the work performed during this contract to assure its operational relevance and utility. Organizational members of the Advisory Team were:

- Headquarters, USAF
- Headquarters, Air Training Command
- Headquarters, Tactical Air Command
- Headquarters, Strategic Air Command
- Headquarters, Military Airlift Command
- Headquarters, Aerospace Defense Command
- Headquarters, Air Force Systems Command
- Tactical Air Command, Tactical Air Warfare Center
- Air Force Human Resources Laboratory
- USAF Aeronautical Systems Division
- Air Force Test and Evaluation Center
- Air Force Manpower and Personnel Center
- Air Force Office of Scientific Research
- Navy Training Analysis and Evaluation Group
- Army Research Institute for the Behavioral and Social Sciences

The authors wish to express their gratitude to the hundreds of people in the United States Air Force, Navy, Army, Coast Guard, NASA, FAA and industry who contributed to this program by providing technical data and participating in interviews and technical discussions during program data collection.

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CHAPTER I

BACKGROUND

REPORT ORGANIZATION

This report is designed to serve two purposes. One is to summarize the content of six other technical reports prepared during the Simulator Training Requirements and Effectiveness Study (STRES). The summary information is contained in Chapters II through VII of this volume. The second purpose is to provide a master index to the content of program technical reports dealing with the design, use, life cycle cost and worth of ownership of aircrew training devices. This information is provided in Chapter VIII.

INTRODUCTION

Aircrew training is an expensive and time consuming endeavor. At one time or another, virtually all known training methods and media have been used to develop operationally ready aircrews and to maintain their skill levels. To meet these training needs in a cost effective manner, the U.S. military has shown increased interest in the use of simulators and related training devices. These training media, known collectively as aircrew training devices (ATD), include cockpit familiarization and procedures trainers, part-task trainers, operational flight trainers, weapon systems trainers, and full mission trainers.

Recent requirements to economize on aircraft fuel have provided strong impetus for the increased interest in ATDs, but other factors have contributed as well. The other factors include increasingly congested airspace, safety during training, cost of operational equipment used for training, and a desire to capitalize on training opportunities that ATDs provide for training that cannot be undertaken effectively, safely or economically in the air.

Because of the advantages simulation can offer over other aircrew training media, it is current Air Force policy that ATDs will be used to the fullest extent to improve readiness, operational capability and training efficiency. Implementation of this policy requires specific technical guidance. Information upon which to base that guidance is sparse, however, and the information that does exist is not always available to those who need it. This phase of the overall STRES program was conceived as a means of identifying, integrating and making available current simulator training information necessary to support relevant Air Force policies. The base of information provides guidance for the enhancement of present training, and focuses research and development needed to enhance future simulation-based training.

The product of this phase of the program is a series of reports that integrate current research data with field operational experience to provide guidance on the design, use, cost and worth of ATDs for specific

training applications. The reports are designed for use by personnel who are responsible for the use of ATDs, including: training program developers and managers; those tasked with developing ATD specifications; instructors and training supervisors; and personnel concerned with training quality control and training effectiveness.

PROGRAM STRUCTURE

The primary objectives of the overall STRES program are to define, describe, collect, analyze and document information bearing on four key areas. The areas are:

> Criteria for matching training requirements with ATD fidelity features;
>
> Criteria for matching ATD instructional features with specific training requirements;
>
> Principles of effective and efficient utilization of ATDs to accomplish specific training requirements; and
>
> Models of factors influencing the life cycle cost and worth of ownership of ATDs.

The Air Force plan for accomplishing these objectives involves a four-phase effort. Phase I was concluded prior to the initiation of the present study. It was an Air Force planning activity that defined and prioritized the total effort. Phase II, the effort described in the series of reports identified below, was a 29 month study that involved collecting, integrating, and presenting currently available scientific, technical and operational information applicable to specific aircrew training issues. Phase II also involved the identification of research and development efforts needed to enhance future simulator training. Phase II was conducted by a team composed of Canyon Research Group, Inc., Seville Research Corporation, and United Airlines Flight Training Center. Phase III is planned to be a research activity that will provide additional information on important simulation and simulator training questions that, as expected, could not be answered based on currently available data. Finally, building on Phases II and III, Phase IV is planned as an Air Force effort to integrate findings, publish relevant information, and provide for updating of the knowledge base as new information becomes available.

A tri-service Advisory Team was formed by the Air Force to help guide STRES. The team participated in two ways. One was to assist in Phase I program planning. The second was to provide guidance and evaluative feedback during Phase II to ensure that products of the phase would be operationally relevant and useful. Both operational users of ATDs and the research community were represented on the Advisory Team.

A principal task of the Advisory Team was to participate in the development of objectives and guidelines for the conduct of the Phase II technical effort. As a focus for the effort, a set of "high value" operational tasks was identified. The tasks selected were those for which potential ATD training benefits were judged to be greatest, and for which information on ATD design, retrofit, use, and worth was believed to be incomplete or lacking. These tasks also provided a focus for identifying questions and issues reflecting the information needs of operational users that were to be addressed during Phase II. The high value tasks identified by the Advisory Team were:

Individual and formation takeoff and landing;

Close formation flight and trail formation, both close and extended;

Aerobatics;

Spin, stall and unusual attitude recognition, prevention and recovery;

Low level terrain following;

Air refueling;

Air-to-air combat, both guns and missiles; and

Air-to-ground weapons delivery.

INFORMATION SOURCES

Information from two sources was used to address Phase II program technical objectives. One source was the professional literature, including books, professional journals and research reports. Approximately 1,100 potentially relevant documents were identified. About 400 of these contained information that was sufficiently current, complete and methodologically sound to be of value to program objectives.

A second information source was the experience of people intimately involved in the design, use and costing of ATDs. Table 1 lists training organizations visited during Phase II to sample this information source. Table 2 lists other organizations visited. Included were ATD manufacturers, research and development organizations, an airline, and operational ATD users in each branch of the military and the U.S. Coast Guard. A broad spectrum of ATD designs and uses was surveyed.

The objectives of the training site surveys varied depending on the type of site visited. Manufacturers and research and development organizations were visited to assess current and projected ATD technology. Research and development organizations were visited to

review ongoing and planned research bearing on STRES program objectives. Operational users were interviewed on a variety of topics in the areas of training accomplished, use of various types of ATDs in accomplishing the training, ATD design characteristics, worth of ownership issues, and life cycle costs. Detailed interview guides were used.

STRES PHASE II REPORTS

Seven reports were prepared to document Phase II. They are:

Semple, C.A Simulator Training Requirements and Effectiveness Study (STRES): Executive Summary. AFHRL-TR-80-63. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Semple, C.A., Hennessy, R.T., Sanders, M.S., Cross, B.K., Beith, B.H., & McCauley, M.E. Aircrew Training Devices: Fidelity Features. AFHRL-TR-80-36. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Semple, C.A., Cotton, J.C., & Sullivan, D.J. Aircrew Training Devices: Instructional Support Features. AFHRL-TR-80-58. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Caro, P.W., Shelnutt, J.B., & Spears, W.D. Aircrew Training Devices: Utilization. AFHRL-TR-80-35. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Allbee, K.E., & Semple, C.A. Aircrew Training Devices: Life Cycle Cost and Worth of Ownership. AFHRL-TR-80-34. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Prophet, W.W., Shelnutt, J.B., & Spears, W.D. Simulator Training Requirements and Effectiveness Study (STRES): Future Research Plans. AFHRL-TR-80-37. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Spears, W.D., Sheppard, H.J., Roush, M.D., & Richetti, C.L. Simulator Training Requirements and Effectiveness Study (STRES): Abstract Bibliography. AFHRL-TR-80-38. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

The remaining chapters of this report summarize the contents of the STRES Phase II technical reports.

Table 1. Training Sites Included In Program Surveys

Sites and Units	Topics of Interest
Altus AFB, OK (MAC) 443rd Military Airlift Wing	C-5 transition training
Castle AFB, CA (SAC) 93rd Bomb Wing	KC-135/B-52 transition training
Denver, CO United Air Lines Flight Training Center	DC-10/B-737/B-747 transition and continuation training
Eglin AFB, FL (TAC) 33rd Tactical Fighter Wing	F-4 continuation training
Fort Rucker, AL US Army Aviation Center	UH-1/CH-47 undergraduate and transition training
Langley AFB, VA (TAC) 1st Tactical Fighter Wing	F-15 continuation training
Mobile, AL US Coast Guard Aviation Training Center	HH-3/HH-52 transition and continuation training
NAS Cecil Field, FL VA-174 and Light Attack Air Wing One	A-7E transition and continuation training
NAS Jacksonville, FL VP-30 and Patrol Wing Eleven	P-3C transition and continuation training
Plattsburgh AFB, NY (SAC) 380th Bomb Wing	FB-111 transition training
Reese AFB, TX (ATC) 64th Flying Training Wing	T-37/T-38 undergraduate pilot training
Tinker AFB, OK (TAC) 552nd Airborne Warning and Control Wing	E-3A transition and continuation training

Table 2. Sites Visited For Management, Research, Development, Engineering and Cost Surveys

Sites and Agencies	Topics of Interest
Pentagon Headquarters, USAF	Management of Air Force ATD resources, and life cycle costs
Randolph AFB Headquarters, ATC	Management of the use of ATDs in undergraduate pilot training, and life cycle costs
Langley AFB, VA Headquarters, TAC	Management of the use of ATDs in fighter aircrew training, development of ATD requirements, and life cycle costs
Eglin AFB, FL (TAC) Tactical Air Warfare Center	Procurement, development and evaluation of ATDs
Luke AFB, AZ (TAC) 4444th Operational Training Development Squadron	Development of training and ATD requirements
Williams AFB, AZ Air Force Human Resources Laboratory (AFHRL/OT)	ATD research
Wright-Patterson AFB, OH Air Force Human Resources Laboratory (AFHRL/LR)	ATD research
Fort Rucker, AL US Army Research Institute for the Behavioral and Social Sciences	ATD research
NASA Langley Research Center Langley, VA	ATD research
McDonnel Douglas Corp. St. Louis, MO	ATD design and research
Singer-Link Corp. Binghampton, NY	ATD design, procurement and evaluation
Navy Training Analysis and Evaluation Group Orlando, FL	ATD research and life cycle costs

Table 2. - (Continued)

Sites and Agencies	Topics of Interest
Naval Training Equipment Center, Orlando, FL	ATD research and life cycle costs
Navy Personnel Research and Development Center San Diego, CA	ATD research and life cycle costs
US Army Project Manager for Training Devices (PM-TRADE) Orlando, FL	ATD research and life cycle costs
Hill AFB, UT (AFLC)	ATD life cycle costs
Holloman AFB, NM (AFTEC)	ATD life cycle costs
Luke AFB, AZ (TAC)	ATD life cycle costs
Offutt AFB, NE (SAC)	ATD life cycle costs
Scott AFB, IL (MAC)	ATD life cycle costs
Travis AFB, CA (MAC)	ATD life cycle costs
Williams AFB, AZ (ATC)	ATD life cycle costs
Wright-Patterson AFB, OH (ASD)	ATD engineering and life cycle costs

CHAPTER II

FIDELITY FEATURES

The first general STRES objective dealt with relationships between training requirements with ATD fidelity features and degrees of fidelity needed to meet the requirements. This topic is addressed in the volume titled: Aircrew Training Device Fidelity Features. Fidelity was defined as: the degree to which cue and response capabilities in an ATD allow for the learning and practice of specific tasks so that what is learned will enhance performance of the tasks in the operational environment. The higher the fidelity of the system, the closer the cue and response capabilities are to their real world counterparts.

Five specific issues were addressed in meeting the fidelity objective: 1) visual system fidelity; 2) flight characteristics fidelity; 3) platform motion systems; 4) force cuing devices; and 5) visual and motion system interactions. Information addressing the use of lower fidelity devices, such as familiarization trainers, procedures trainers and part task trainers, is addressed in the report: Utilization of Aircrew Training Devices. Each of the five issues addressed in the fidelity volume is summarized below.

VISUAL SYSTEM FIDELITY

Visual systems providing simulated out of cockpit views are considered necessary for ATD training of contact flying skills. Research studies and operational experience support the position that training in visually equipped ATDs will transfer in a beneficial way to performance in the aircraft for many tasks. However, available scientific and operational information provides little useful guidance on how to design ATD visual systems to maximize training effectiveness.

Research and operational experience with visually equipped ATDs indicates, rather solidly, that training in such devices will transfer (carry forward) to inflight performance for the following tasks: individual aircraft approach and landing; and contact flight. It can be said with some confidence that ATD training likely will transfer positively for: stall recognition, prevention and recovery; formation flight; air refueling; and air to ground weapons delivery. No conclusions about transfer of training can be made for aerobatics or air to air combat tasks.

Visual system technology is relatively new, and experience with it is limited. Therefore, the following issues cannot be resolved using presently available information: 1) how to best use visually-equipped ATDs; 2) effects of instructional variables, such as instructor location; 3) ATD use for skill maintenance; 4) effects of pilot aptitudes; 5) effects of pilot experience levels; and 6) effects of visual system characteristics.

The last issue is a considerable problem because science has not been able to produce a usable model of human visual perception in complex tasks. As a result, there is no objective way of relating details of the visual scene (e.g., cues presented, field of view, resolution, color, texture and scene content) to the process of human information extraction and use. Such a model is needed in order to replace speculation and subjectivity in visual system design with perceptually-centered design guidelines that can be related to training effectiveness.

The subject of visual system fidelity for simulator training is obviously most complex. In order to adequately address the many related issues, the STRES chapter on this subject (III) discusses training effectiveness information on a case-by-case basis with specific findings reported from both the literature and operational experiences.

In addition, the report covers visual system functional requirements, including discussions of field of view, color, virtual vs. real image displays, various scene generation and display technology, image improvement methods, scene content and human perceptual learning.

As discussed in this report, the scientific literature can not be directly applied to the important questions being raised regarding the actual correlation between various aspects of visual fidelity and operational performance (training effectiveness). This information shortfall has been recognized by others, and an intense series of investigations has begun that may greatly extend the existing data base. The Integrated Cuing Requirement Study (ICR) is one such study. It is important to note that the greatest training/cost "payoff" is expected to come from advances in visual simulation. Consequently, limited research funds should be directed towards visual system improvements as one of a number of priority issues.

FLIGHT CHARACTERISTICS FIDELITY

Flight characteristics fidelity (FCF) is the extent to which aircraft control and response characteristics are reproduced in an ATD. It is the extent to which the ATD "feels" like the aircraft it represents. Factors that can influence FCF are: control system fidelity; aerodynamic modeling; cockpit display fidelity; motion cue fidelity; visual display system fidelity; evaluation pilot training and expectations; and the nature of the pilot-in-the-loop processes used to evaluate FCF.

Historically, designing ATDs to have high FCF has suffered from inadequate aircraft data and from lack of quantitative, objective means of measuring ATD dynamics with respect to aircraft flight characteristics counterparts. Steps are being taken in the military to overcome both of these deficiencies. One consequence should be a lessened future reliance on subjective "tweeking" by acceptance pilots

and simulation engineers. Expanded use of engineering test pilots for final system "tweeking" also should expedite the FCF acceptance process and result in better accepted ATD flight characteristics fidelity.

High FCF is very important to user acceptance of ADTs that "fly". The research literature suggests that departures from high FCF may not significantly detract from an ATD's training effectiveness, at least for the final approach and landing task. The same may be true for other tasks where ATD training involves learning much more than precise control skills. On the other hand, the issue of aircrew safety is involved, and objective data simply are lacking that deal with FCF requirements for effective, safe training on the broad spectrum of flying tasks required by military missions. It is reasonable to say, however, that many ATD users have largely unjustified concerns that negative training will result if FCF is not extremely high.

Pursuit of high levels of FCF is the rule. Yet, many ATDs exist which, in various ways, have FCF shortfalls. Based on the meager evidence that is available, guidelines are given for estimating influences of FCF on training effectiveness as a function of: pilot experience; pilot skill level; task difficulty; and first-flight proficiency requirements. The guidelines are general. Their primary intent is to encourage the objective test and evaluation of training that actually can be accomplished in ATDs with FCF shortcomings.

Flight characteristics fidelity is addressed in Chapter IV of the fidelity report.

PLATFORM MOTION SYSTEMS

Platform motion systems that provide from three to six degrees of freedom of cockpit movement are relatively common in modern operational flight trainers, full mission trainers, and certain part-task trainers. Motion system hardware, computing and software variables all can impact the quality of the motion cues that are generated. Cue quality, in turn, can influence pilot acceptance and, possibly, training effectiveness.

Platform motion cuing is assumed to benefit training because it contributes to the realism of the training environment. Research on the training effectiveness of motion cuing, although extensive, is not conclusive. Anecdotal evidence was often cited indicating that, in some cases, pilots are unawares of whether platform motion systems have been turned on or off. These cases almost always involve ATDs with out-of-cockpit visual display systems, which also can provide motion cuing information.

Much of the motion cuing research has dealt only with pilot performance in the simulator. Relatively few studies have investigated differences in performance in actual aircraft following simulator training with or without platform motion cues (i.e. transfer of training experiments). Recent transfer of training experiments

investigating the impacts of platform motion cues during ATD training have found that the presence of platform motion cues did not lead to improved pilot performance during subsequent inflight tests. A number of these studies have been criticized, however, on the basis that lags in the motion systems and problems in the computation and drive algorithms of the equipment used in the tests make the findings difficult to interpret. The measurement of pilot performance in flight also is a difficult task, and the possibility remains that the inflight measures used were insensitive to subtle differences in pilot performance and technique. Finally, the available transfer of training experiements all involved tasks where cockpit motion feedback was the direct result of pilot control inputs, rather than disturbances outside the pilot-aircraft control loop.

One current line of reasoning seems to account for apparently contradictory findings from many studies and experiences dealing with the training value of motion cuing. Motion cues are viewed in two categories: maneuver motion cues; and disturbance motion cues. Maneuver motion is a pilot-initiated, closed loop function. The most important element is that the pilot expects the motion cue feedback; thus, maneuver motion confirms execution and control. It does not necessarily tell the pilot anything new. Disturbance motion, on the other hand, is not pilot initiated. Examples include yaw following engine failure, buffet, turbulence or response to aircraft instabilities. Disturbance cues provide new information to the pilot, who must react to control the aircraft.

It may be that disturbance motion cues are important to ATD training, but that maneuver motion is not. Although much of the available evidence supports this viewpoint, there are no relevant transfer of training data to support the assumed importance of disturbance motion cues during ATD training. Also, evidence has only recently become available addressing the issue of whether out of cockpit visual systems can provide adequate maneuver and disturbance cues for training purposes. It is possible that platform motion cues may contribute little to training for certain specific conditions in the presence of adequate visual system cues, but the evidence is incomplete. It also was recognized that tasks, aircraft simulated, maneuver rates and pilot skill and experience levels are complex interactions; and research findings, therefore, often are difficult to generalize.

Some anecdotal evidence was found suggesting that motion cuing may be necessary for ATD training involving high workload levels which include pilot time-sharing between flight control tasks and sensor operation tasks in a high threat environment. It is possible in this or similar cases that motion cues act as disturbance cues by alerting the pilot to make corrective control inputs. The training value of motion cuing in very high workload situations, especially using sensors, is an issue requiring further research.

Other research has shown that when motion cues are provided in the simulation, pilot behaviors such as instrument use, the use of flight

controls, and tracking performance in simulators are more apt to be similar to these behaviors in the aircraft. However, no evidence exists on whether these performance details are meaningfully improved in the aircraft following ATD training incorporating platform motion. Available evidence suggests that pilots can readily adapt their control and scan strategies to inflight requirements.

Chapter V of the fidelity report deals with these and related issues.

FORCE CUING

Force cuing devices currently include: G-seats; G-suits; seat shakers; helmet loaders; arm loaders; and visual system greyout/blackout capabilities. This family of device capabilities is assumed to add to ATD realism and, therefore, to training effectiveness because of a closer match between stimuli present in ground-based and inflight training environments.

Little training research or training effectiveness literature exists for force cuing features because they are quite new. At issue are the relevance of the cues they can provide for training in ATDs; the transfer, or carry forward of force cue-supported learning to the air; their interaction with visual cues; and their use, in some instances, as substitute sources for cues produced by platform motion systems.

It is possible that the value of some force cues, such as those provided by G-seats, will depend on whether the cues provide maneuver or disturbance information. The value of other cues, such as those produced by G-suits, helmet loaders and arm loaders, may hinge on the student's first having inflight experience with the cues so that he can use them meaningfully in the simulation. All of these issues require additional research before meaningful conclusions can be drawn.

Current information on the design and use of force cuing features is presented in Chapter VI of the fidelity report.

VISUAL-MOTION INTERACTION

The human senses motion information in many ways: visually; through vestibular sensors in the inner ear; and through pressure receptors throughout the body. Information from these sources is neurologically linked. From birth, the human is conditioned to rely on synchronized information from these multiple sources.

For those tasks dependent on such cues, their occurrence should be synchronized, as in the real world. This is not always achieved due to time delays from various cue sources. Delays and lags can influence the pilot's ability to control an ATD, device acceptance, the likelihood of nausea in the ATD, and possibly training effectiveness.

Very little empirical data exist on tolerable limits or desirable minimums for asynchrony among visual, motion and cockpit display cues. The meager evidence that exists suggests that motion cues should not follow visual cues by more than 125-150 milliseconds for large bodied aircraft, and not more than 50 milliseconds for high-performance aircraft.

Mechanical and programming techniques exist to reduce the time delays between control input from a steady state and simulator movement cues. In general, these delays come from three sources: iteraction rate; bandpass of the hydraulic servos; and drive algorithms. Current engineering estimates are that iteration rates of at least 30 Hz and a bandpass of at least 4 Hz for the servos will decrease these delays.

These issues are dealt with in Chapter VII of the fidelity report.

CHAPTER III

INSTRUCTIONAL SUPPORT FEATURES

The second general STRES objective dealt with relationships between instructional support features and specific ATD training requirements. These issues are addressed in the volume titled: Aircrew Training Device Instructional Support Features.

INSTRUCTIONAL FUNCTIONS AND FEATURES

Instructional support features include ATD hardware and software capabilities that permit instructors to manipulate, supplement, or otherwise control student learning experiences in order to improve the rate and level at which skills are mastered. Virtually all ATDs incorporate at least some instructional support features. Features such as record/replay and problem freeze have been incorporated into ATDs for a number of years. Others, such as automated controllers and automated performance measurement, are relatively new technologies. Still others, such as fully adaptive training, are in laboratory stages of development.

The value of an instructional support feature lies in its proper design and use to support the instructional process and to enable students to learn faster and perform better. The instructional features volume is organized around five functions which are used to define significant facets of the instructional process that are influenced by ATD design. The five functions are: 1) instruct; 2) monitor and evaluate performance; 3) control/individualize training; 4) controller function; and 5) prepare, brief and debrief. Separate chapters address each instructional function and discuss instructional support features related to each. Not all relevant issues fell conveniently into any of the instructional function categories. Therefore, additional chapters address instructor/operator console design and location, and instructor/operator training as it relates to the use of ATD instructional support features.

The following instructional support features are addressed: 1) freeze; 2) automated demonstrations; 3) record and replay; 4) automated cuing and coaching; 5) manual and programmable sets of initializing conditions; 6) manual and programmable malfunction control; 7) ATD-mounted audio visual media; 8) automated performance measurement; 9) automated performance alerts; 10) annunciator and repeater instruments; 11) closed circuit television; 12) adaptive training; 13) programmed mission scenarios; 14) automated controllers; 15) graphic and text readouts of controller information; 16) computer controlled threats; 17) computer managed instruction; 18) recorded briefings; 19) remote replay for debriefing; and 20) hard copy printouts of performance information. A general finding was that the use of instructional support features is directly related to pilot skill level and associated instructional requirements rather than the tasks being trained.

Each of the twenty instructional features is discussed, as appropriate, in terms of : 1) its operation; 2) related features; 3) instructional values; 4) observed applications; 5) utility (use-related) information; 6) related research; and 7) design considerations.

INSTRUCT

Chapter III of the instructional support features volume addresses features related to the instruct function, which was defined as: providing correct procedures; providing technique information; critiquing; and providing feedback information. Recommendations are made for the design and use of the following features: freeze; automated demonstrations; and record and replay. Potential benefits as well as possible drawbacks of automated cuing and coaching are presented. The need for a workable automated performance measurement system is discussed as a prerequisite for meaningful automated cuing and coaching.

Manual and programmable sets of initializing conditions also are discussed as highly accepted means for simplifying ATD operations and making efficient use of training time. Potential benefits of programmable malfunction control are presented in terms of unburdening the instructor from routine tasks and promoting standardized training. Drawbacks associated with overburdening the student with malfunctions also are discussed, together with design recommendations to alleviate this potential problem. ATD-mounted audio/visual media, such as sound/slide systems mounted at ATD windscreens, were found to standardize instruction, promote self study, and unburden instructors. Experience indicates that all three goals are achievable for training of procedural tasks.

MONITOR AND EVALUATE PERFORMANCE

The topic of Chapter IV is monitor and evaluate performance. These two functions are addressed jointly because they are mutually supportive. Monitoring is observing or gathering relevant performance information; evaluating is making decisions about performance using information gathered through monitoring.

Automated performance measurement is an emerging instructional technology that is not yet at the stage where handbooks can be written on how to design valid, usable automated measurement systems. Each application requires professional design and diligent research and development experimentation. Computer measurement systems found on some current ATDs do not qualify as workable automated measurement systems, in part because measures are inappropriate and in part because they inundate the instructor with data.

Automated performance alerts are intended to enhance and simplify performance monitoring and to provide performance information to instructors and students. Their effectiveness hinges on adequate

automated performance measurement. They can prove distracting, depending on how the alerting capability is implemented.

Repeater flight instruments and annunciators that signal the occurrence of events (e.g. control positioning) are discussed with respect to instructor/operator consoles that are remote from the student's training station. Design possibilities and related questions are presented dealing with the use of time-shared electronic display media as ways of presenting to instructors only the information needed to monitor and control the task being trained and, in doing so, to simplify the physical design and layout of instructor/operator consoles. With proper instructor training and proper display design, electronically displayed console information was found to be practical and accepted.

Chapter IV closes with a discussion of experience in using closed circuit television to monitor performance and techniques of students in ATD cockpits that do not accommodate the presence of an instructor. Historically, the use of closed circuit television has not worked well in this role because of field of view, resolution and viewing angle limitations.

CONTROL AND INDIVIDUALIZE TRAINING

Control means to direct or regulate training events. Individualizing training is a special case of controlling where training is tailored to the student's unique skill levels and abilities. Chapter V addresses these issues and presents information on automated adaptive training and programmed mission scenarios.

An ATD adaptive training system is an automated training system that controls the specific training tasks and/or the difficulty of the tasks to be performed by each student. They are controlled in a manner that allows each student to progress through a training syllabus in a sequence tailored to his unique skills, in a minimum amount of time, and with the assurance that acceptable skill levels are achieved for each task learned. Adaptive training systems require a computer-resident syllabus, performance evaluation and performance problem diagnostic automated measurement capabilities, and instructionally optimized computer logics to control and sequence training events. Adaptive training systems are not yet ready for operational use. They hold promise for unburdening instructors through automation of at least some training decisions, and the tailoring of training to individual student needs. Expert opinion is that adaptive training would be most applicable to undergraduate aircrew training, with possible applications in transition training.

Programmed mission scenarios essentially are non-adaptive training exercises consisting of highly structured sets of events. Present uses are limited to training exercises involving penetration through known high threat environments. Additional applications are presented where

standardization of training and evaluation are meaningful in undergraduate, transition and continuation training.

CONTROLLER FUNCTION

Instructors and/or ATD operators often perform the roles of air traffic controllers, tactical controllers, or control the actions of simulated airborne threats. Technology presently or soon available to assist in these roles is presented in Chapter VI.

One example of this new technology is the automated controller. These computer-based systems "understand" at least limited amounts of human speech, and generate speech that can be understood by humans. Automated controller systems rely on mathematical models of the operational situation being controlled, including a model of controller actions. The ability to measure actual student performance relative to desired performance is required for input to the controller model. Instructionally, automated controllers offer potentials for unburdening instructors from routine controller tasks (e.g. GCA), enhancing accurate and timely controller message transmissions, and providing a new, natural medium for students to communicate with computer-based systems. Limited experience with these new systems indicates that further improvements in computer speech recognition technology are required for many aircrew training applications; the technology is advancing rapidly.

A number of ATDs provide instructors with pictorial situation displays showing aircraft position relative to geographic reference points, other aircraft, or desired flight profiles. Electronic display media to show these relationships in graphic format are being used successfully and are accepted in air intercept, terminal area navigation, final approach and landing, and air combat training. Chapter VI presents a number of considerations for effective design and use of these display types.

The last issue addressed in the chapter is computer controlled adversaries (iron pilots). These automated controllers have been successfully applied in visually-equipped ATDs used for air combat training. Properly designed, they unburden the instructor from controlling the adversary and provide realistic adversary maneuvering. When computer controlled adversaries are combined with an automated performance measurement system, improved information describing engagement outcomes can be obtained.

PREPARE, BRIEF AND DEBRIEF

Three instructional functions are discussed in Chapter VII. Prepare is defined as working out beforehand the details of what is to be trained and how training is to be undertaken during a period of ATD instruction. Potential values of a computer managed instructional (CMI) system that compares a student's training history with a standard training syllabus are presented as means of efficiently focusing the

preparation of ATD session content on student performance deficiencies. CMI systems tailored specifically for this aircrew training application are not known to exist at this time, but general design guidelines are given.

Briefing is defined as giving final training session instructions, coaching through mission events in advance, questioning to determine readiness for the upcoming training, and providing remedial instruction in weak areas. Standardization values of recorded briefing content are discussed with respect to highly structured ATD training exercises. The proper use of recorded briefings remains a research issue.

Debriefing is defined as reviewing training events with the goals of evaluating performance, providing instruction aimed at overcoming performance deficiencies, and providing positive feedback on tasks performed well. The roles of automated performance measurement and CMI systems are presented as sources of debriefing content. The use of pictorial situation displays for post-session debriefing also is presented, as are the potentials of remote replay terminals. Hard copy printouts of performance data are discussed. In general, pictorial information and highly summarized numerical performance data are useful memory aids for debriefing. Hard copies of detailed numerical performance data are not used by instructors or students.

INSTRUCTOR/OPERATOR CONSOLE DESIGN AND LOCATION

Chapter VIII of the instructional support features volume addresses these issues in a two part chapter. The first part deals with console design, emphasizing consoles that are located remotely from the student's work station. References are made to design guidelines presented in earlier chapters of the volume. Emphasis is given to the need for careful analysis of instructor tasks that the console is to be designed to support before console design is undertaken, so that its support of training is its design foundation. Key issues to be considered are described.

Part two of Chapter VIII deals with the issue of whether the instructor should be located with the student or located at a console that is removed from the student's work station. This difficult issue directly involves perceived needs for physical fidelity of the student's cockpit work station. Military ATD designers are reluctant to incorporate an instructor station in an ATD if a similar station or position does not exist in the actual aircraft. On the other hand, instructors who are located with students, as in transport ATDs, strongly feel that effective, efficient instruction relies heavily on the instructor's being able to work directly with the student and observe his behavior. Principles of effective instruction suggest that locating the instructor with the student is beneficial, particularly during initial learning. Alternatives are suggested that would preserve cockpit physical fidelity when this is desirable, but also would allow the physical presence of an instructor as needed.

INSTRUCTOR/OPERATOR TRAINING

The best training equipment, by itself, will not produce operationally ready aircrews. The equipment must be used effectively to achieve this goal. ATD instructor and operator training is central to effective and efficient use of ATDs. Chapter IX addresses this issue.

Program surveys showed that typical instructor training focuses on how to do the tasks to be trained, and on administrative matters. On the average, only three hours of instruction were devoted to "how to teach." Also, instruction on how to operate ATDs typically is left to informal on the job training.

Improved instructor training, emphasizing principles of instruction and the use of ATDs as flexible training tools, was identified as a very important issue in improving aircrew training. Issues involved include training in principles of learning and instruction; instructor quality control; and the use of ATDs as flexible instructional tools. One source of guidance for improving instructor training is the instructional features volume in which principles for the use of instructional support features are presented. Other, related issues are discussed in Chapter VI of the volume titled: Utilization of Aircrew Training Devices.

CHAPTER IV

UTILIZATION OF AIRCREW TRAINING DEVICES

The third general STRES objective addressed principles of effective and efficient use of ATDs. This objective is the topic of the volume titled: Utilization of Aircrew Training Devices.

Strengths and weaknesses of practices in ATD training programs observed during this project are related to the way the following issues are addressed and the related problems resolved. The first is the complexity of skill learning involved, and the adaptation of ATD usage to basic requirements for effective and efficient skill training. The second involves the appropriateness of the structure of ATD training for the skills being trained and the capabilities of available devices. The third addresses the overall responsibilities of instructors in harmony with requisites for effective instruction, and instructor preparation to teach and exploit ATD capabilities. The fourth involves steps to be taken to ensure the development and maintenance of attitudes among ATD personnel and students that are necessary for a favorable training environment. The fifth issue centers on assessing the effectiveness and efficiency of ATD training, and distribution and use of the findings to improve ATD training. The sixth issue addresses steps to be taken to ensure maintenance of training quality after an ATD program has become operational.

COMPLEXITY OF SKILL LEARNING

By and large, training in ATDs is highly patterned after comparable inflight training. Students simply practice skills in devices, and feedback and guidance are provided according to instructors' intuitive analyses of student needs. Various advanced ATD capabilities and instructional support features are used; but just as commonly some are not used at all, either because they are perceived to reduce realism or because instructors have not learned how to use them.

Within this context, emphasis is given to the need to attend to particular cue and response discriminations that underlie skill performance, because the status of these discriminations at a given point in training should be the basis for deciding whether to provide feedback and guidance, and in what form. Many instructors could adapt use of these factors to students' needs, but more often feedback and guidance are used according to a routine plan that does not consider students' actual needs on a moment-to-moment basis. Many ATDs are specifically designed to optimize use of these factors; the conditions for exploiting feedback and guidance are given.

A serious issue in ATD training is the need to recognize the fundamental role of the mediational processes in all skill learning. Mediation refers to everything a person does between receiving a stimulus and responding to it, including deriving cue information from

the stimulus, interpreting and processing the information, selecting and monitoring the response, etc. Both cognitive and motor mediations are involved.

Complex learning is possible because mediation is possible. Transfer of ATD training to aircraft performance depends on appropriate forms of this process. The need to deliberately emphasize mediational development and use during ATD training is described, and principles for developing mediation are given.

Chapters III and IV of the utilization report are devoted to examining the complexities of learning and explaining their implications for ATD training.

STRUCTURE OF ATD TRAINING

There are many ways to structure specific aspects of ATD training to provide effective and efficient instruction. Nevertheless, certain general requirements must be met regardless of the structure used. First, training allocated to ATDs must be consistent with device capabilities. However, depending on the students' capacities to substitute mediation for physical realism, and the extent to which instruction exploits these abilities, a variety of tasks can be trained using ATDs with obstensibly limited features. Guidelines are given for meaningfully using devices with perceived limitations.

Second, tasks must be separated, and grouped, in ways that promote effective and efficient learning. Depending on the task and abilities of the student, particular training sessions may need to focus on part-tasks or grouped tasks. There are ways to decide which approach is needed, and they are based on the processes of skill acquisition. Similarly, there are ways to promote the functional integration and coordination of skills whether learned separately or together. These ways are presented.

Third, the duration and frequency of practice should be such that progress is made during skill acquisition and the skills learned are retained. Factors to be considered include the need to reduce interference on some occasions, and to promote the accommodation of interference on others; the amount of forgetting that occurs between practice sessions and over time after skills are learned; and the level of mastery previously achieved by students. The nature of individual tasks practiced in sequence is also an important factor in determining duration of single ATD sessions, especially for less experienced students. Guidelines are given for taking these factors into account in training program development.

Fourth, the effectiveness of ATD training in some skills can be affected by when it occurs relative to academic training and aircraft experience. For some tasks, later ATD practice can provide concrete meanings for cues and actions learned abstractly in academic training.

In other cases, academic training may be almost meaningless unless students already have had certain ATD (or aircraft) experiences. Similarly, experiences in aircraft may need to precede ATD training for some tasks, and follow it for others. Chapter V examines bases for structuring ATD training programs with respect to these four considerations.

ATD INSTRUCTORS

As a rule, the more effective ATD training programs observed during site visits were those in which instructors had been trained "to teach" and were taught specifically how to use ATDs and their instructional support features. These programs also minimized non-instructional duties that interfere with teaching performance. In most effective programs, ATD instructors usually were considered an elite group by their peers and students. To the extent the reverse of these conditions was true, training programs appeared to have been negatively affected. Chapter VI of the utilization report discusses the effects of selection, training and management of instructional personnel on the quality of ATD training.

ATTITUDES TOWARD ATD TRAINING

Attitudes of instructors toward ATD training can be of critical importance for the success of an ATD program. Not only do instructor beliefs regarding device training determine how devices are employed, but they affect the attitudes of students toward the value of ATD practice. The problem of attitudes goes beyond instructors and students, however. Just as students "model" instructors' opinions, so instructors reflect the beliefs of their peers and supervisors. The need for fostering favorable attitudes toward ATD instruction at the organizational level are addressed in Chapter VII.

Chapter VII discusses causes and conditions leading to favorable and unfavorable attitudes toward ATD training. These causes and conditions relate to how design requirements for ATDs are determined, the manner of introduction of an ATD to a training unit, and how ATD training is conducted and managed. The need for an atmosphere of professionalism among instructors also is explained.

ASSESSMENT OF TRAINING EFFECTIVENESS

Formal assessment of the training effectiveness of operational ATD training programs is practically non-existent. Therefore, there are no hard data to identify shortcomings of programs, or to convince doubting managers and instructors of the value of ATD training. It is fortunate that one does not have to rely on existing documentation of training effectiveness to establish that ATD programs are worth the effort. Chapter VIII is devoted to explaining what is involved to provide guidance to personnel who must judge the adequacy of evaluation studies.

MAINTAINING ATD TRAINING EFFECTIVENESS

Given an effective ATD program, its quality can be maintained only if it is adjusted quickly to modifications in training requirements and in design of the aircraft. Good training practices must be maintained and not allowed to evolve in undesirable directions as training personnel are replaced or student quality changes. Attitudes toward ATD training also may change for the worse over time, and management may increasingly neglect the program as its novelty wears off.

Problems such as modifications in training requirements and aircraft should be resolved quickly. Other problems, especially those leading to a gradual program deterioration, may not be noticeable until serious damage has occurred. Training quality should be monitored and corrective action taken on a regular basis. Chapter IX of the utilization report discusses these issues and presents guidance for maintaining training program effectiveness.

CHAPTER V

LIFE CYCLE COST AND WORTH OF OWNERSHIP

The fourth objective of the program was to develop models of the factors influencing the life cycle costs and worth of ownership of ATDs. The life cycle cost model permits decision makers, through the use of cost factors and actual cost data, to determine costs of training device alternatives, throughout their usable life. The model also can be used to predict costs of simulators and simulator features; determine the factors that influence these costs; and identify, quantify, and compare the costs of an ATD with other flying training costs. A separate worth of ownership assessment procedure was developed as a decision making aid to evaluate the merit of alternative ATD designs and training uses that are not easily evaluated on the basis of costs alone.

COST MODEL DEVELOPMENT

In developing the life cycle cost model, emphasis was on actual cost factors and data obtained from the Air Force accounting system, rather than theoretically derived or estimated costs. Six basic cost areas were identified: 1) acquisition; 2) research and development; 3) staff overhead; 4) test and evaluation; 5) operation and maintenance; and 6) logistics. Specific Air Force sources of cost data that were used are reported, and data gathering procedures are described. Where existing Air Force data were insufficient, such as subsystem operation and maintenance costs, supplementary data from airline experience are provided.

Based on the six major cost categories, hierarchy models were developed to allow base, command, and Air Staff users of the model to examine cost factors at the level of detail required to meet their specific needs.

The Level 1 base user model allows determining of specific and detailed direct and indirect costs of training equipment. The Level 2 command user model deals with overall training system costs for a particular base as well as command overhead costs for support of that base. The Level 3 staff user model determines overall costs of training for a particular command, research and development monies appropriated for ATDs, and Air Staff overhead directed toward flying training.

The cost model is very flexible. It can satisfy the requirements of a variety of uses and users. Management at base levels, command levels, and Air Staff levels can use the appropriate portions of the STRES cost model to meet their requirements.

In developing the STRES cost model and the methodology for collecting actual cost data, it was found that changes in the Air Force cost accounting system might provide more accurate training device cost data. Where applicable, specific recommendations for changes to the Air

Force cost accounting system are made, with recognition that the system was not established to track cost data of the detail sought in this study.

COST MODEL USES

The STRES life cycle cost model was developed in a way that allows it to be used for trade-off decisions, such as the cost impact of adding a major subsystem, (e.g., a visual system) and to assist in determining life cycle cost impacts of various subsystem alternatives.

A considerable amount of unclassified cost data was collected during on-site visits at various organizations. These data and commercial cost data are presented in the appendixes of life cycle cost and worth of ownership report.

COST MODEL PROCEDURES

The reader is provided with the overall model, the hierarchical models, and a detailed description of the components, elements, and sub-elements that comprise the models. Explanations are provided on how each relates to total flying training costs. The report explains where and how to collect cost data for the models. It should be noted that there is a significant difference between the STRES model and other models; the STRES model uses all empirical cost data for its inputs rather than theoretical cost information.

WORTH OF OWNERSHIP ASSESSMENT

Worth refers to the subjective or intuitive issues and factors by which objects, courses of action and systems often are evaluated. These issues and factors often can be vague and inconsistent, and the ones used often vary from one decision maker to the next. The general goal of a worth of ownership assessment is to identify the system whose capabilities best meet mission requirements. Systematic assessment of worth of ownership can aid considerably in structuring communication among decision makers, and can be a significant aid in the total decision process.

A worth assessment procedure is presented in Chapter IX of the life cycle cost and worth of ownership volume. The procedure focuses on the following six general steps: 1) define desired mission objectives; 2) define alternative system approaches; 3) determine which worth issues and factors are relevant; 4) determine the worth of system alternatives for fulfilling mission requirements; 5) select the best alternative or define a new, more responsive system; and 6) document rationale, assumptions, analyses and conclusions.

A total of 65 detailed worth factors is presented. The factors are organized into the following eight general issues: 1) political; 2) management/administrative; 3) resource management; 4) operations and

tactics; 5) training; 6) personnel; 7) training effectiveness; and 8) ATD technology. A method is presented for selecting issues and factors relevant to specific ATD worth evaluations, and for assigning worth indices to each factor and each ATD design and use alternative being evaluated. A computational example is presented. Validation of the STRES ATD worth assessment procedure should precede its operational use since it is a new procedure.

CHAPTER VI

FUTURE RESEARCH PLANS

The future research plan volume of the STRES report series identifies research needed to fill in information gaps that were anticipated from the outset of the study. As anticipated before the initiation of STRES Phase II, complete, high confidence answers could not be found for some major questions concerning ATD design and use. In some instances, information concerning a given question had never been collected systematically, or the practical utility of a given training concept or ATD design feature had never been addressed. In other cases, prior research could not be applied directly to current training questions. That is why it was recognized at the onset of the program that subsequent research and integration phases would be required.

The objectives of developing future research requirements were: 1) to determine the issues and questions that needed to be addressed in future research; 2) to prioritize the issues with respect to current Air Force ATD training information needs; and 3) to develop recommended plans for future Air Force ATD training research to address issues with the highest priorities. The general approach involved integrating the research problem appraisal that occurred as a result of the STRES literature review and site visits, with the general experience of STRES contractor and government project personnel.

APPROACH

The first activity was to determine current information needs regarding relationships between training effectiveness and: 1) device fidelity factors; 2) device instructional support features; and 3) device utilization factors. Inputs for this analysis were derived from the review of the literature concerning ATD training effectiveness and information concerning current ATD training practices and problems identified during site visits. The product of this analysis was a preliminary listing of potential research topics.

The preliminary listing then was compared with existing research plans and the progress being made by major government ATD training research organizations. Topics that duplicated or overlapped these plans were eliminated from further consideration.

Topics that were selected for further consideration then were prioritized by project team personnel in terms of the importance or criticality of the research topic and the expected benefits to be derived from the research findings. Topics that were classified as having the highest priority were used during the detailed research plan development. The listing of research topics, categorized by research priorities, was submitted to the Air Force for review, coordination, discussion and modification. A final list of 21 high priority research topics resulted.

RESEARCH RECOMMENDATIONS

The future research plan report presents detailed plans for the 21 high priority topics; brief research plans for additional, lower priority topics; and a master listing of all topics considered. Detailed research plans provide the following information: 1) statement of the problem; 2) research overview; 3) analytic requirements; 4) experimental method; 5) research subject sample; 6) data collection and analysis plans; 7) facilities; and 8) schedule and personnel requirements.

The 21 high priority research topics are listed below under two general categories: simulation technology; and utilization technology.

Responsibility for implementing these and other research plans resides with the Air Force (STRES Phase III). It also must be recognized that STRES research plans will require continued review and revision as additional research findings become available.

Simulation Technology

1. Development and validation of a model for predicting ATD training effectiveness

2. Design requirements for ATD use in proficiency evaluation

3. Determination of external visual cue requirements

4. Scene content alternatives for presenting visual cues

5. Determination of motion and force cue requirements

6. Alternative mechanisms for providing motion and force cuing

7. Alternative strategies for presenting external visual scenes to the instructor

8. Effects of instructor location on training in visually-equipped ADTs

9. Requirements for delayed remote displays of performance

Utilization Technology

10. Techniques for providing feedback and guidance

11. Assessment of trainee performance

12. Assessment of crew performance

13. Training program requirements for ATD instructors

14. Techniques for evaluating the proficiency of ATD instructors

15. Techniques for the use of self-instruction in ATDs

16. Training and evaluation of advanced cognitive skills

17. Use of ATDs for tactics development and dissemination

18. Techniques for crew instruction

19. Techniques for extended team training

20. Operational training program development

21. ATD design requirements and techniques for teaching selected operational tasks

CHAPTER VII

ABSTRACT BIBLIOGRAPHY

Approximately 200 comprehensive abstracts of research, development and other reports are presented in the volume titled: Abstract Bibliography. The abstracts are highly detailed and are intended to provide meaningful background information to users who normally do not have direct access to relevant professional literature. Included in these abstracts are most of the highly relevant documents cited in the other volumes of the STRES report series. They provide readily available in-depth discussions of the research and development drawn upon in the content of the other reports.

Each abstract includes a complete citation to the original document and a statement of its purpose. Where applicable, each provides a description of the approach used in the study, a summary of findings, the author's conclusions, and suggestions for further research. For highly detailed documents, such as handbooks or procedural guides for which a detailed abstract was not feasible, the intended user groups are identified and the major thrusts of the document are explained. Except where clearly irrelevant, an evaluation accompanies each abstract which identifies major weaknesses in the study, as well as major strengths if they are not readily apparent from the abstract itself. A general evaluation statement also is presented.

A number of other items of information are listed separately from the body of the abstract. These include, as appropriate: abstractor's comments; cross-references; dependent and independent variables used; measurement; statistical and special analytic techniques; the type of ATD system or subsystem of concern; types of subjects used in experiments; numbers of pages and references cited; type of research conducted; the organization that conducted the study; the sponsor of the study, with contract/project/task numbers; and the publisher of the document. Also given are any descriptive or supplementary notes provided with the document, the report number(s), report date, type of publication, and distribution statement (for government documents). The title and author(s) are also listed separately as well as in the citation.

All abstracts were prepared to facilitate their entry into Air Force data bases so that this additional information can be readily integrated with existing data base content.

CHAPTER VIII

INDEX TO STRES TECHNICAL REPORTS

The STRES program addressed a broad set of issues dealing with ATD design, use, cost and worth of ownership. These issues are complex and many are interrelated. This chapter is unusual for an executive summary report. It is intended to assist readers in identifying and locating relevant information contained in the four program main technical reports.

The chapter has two specific objectives. One is to provide readers with a convenient overview of topics addressed in the following four technical reports: ATD Fidelity Features; ATD Instructional Support Features: Utilization of Aircrew Training Devices; and ATD Life Cycle Cost and Worth of Ownership. A second objective is to identify specific report volumes and pages within each volume where major topics are addressed.

The following pages present key elements of content addressed in each of the four program main technical reports. Key topics of each report are presented separately, and are organized by chapter.

FIDELITY VOLUME INDEX

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FIDELITY VOLUME INDEX
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FIDELITY VOLUME INDEX
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INSTRUCTIONAL FEATURES VOLUME INDEX

INSTRUCTIONAL FEATURES VOLUME INDEX
(Continued)

INSTRUCTIONAL FEATURES VOLUME INDEX
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UTILIZATION VOLUME INDEX

UTILIZATION VOLUME INDEX
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COST/WORTH VOLUME INDEX

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